

Scientific cooperation to support nuclear arms control and disarmament

1 Summary

As the international community prepares for the Review Conference of the Nuclear Non-Proliferation Treaty (NPT), taking place in May 2010, it is timely to highlight how the scientific community can support nuclear arms control and multilateral disarmament.

Despite political challenges, progress can still be made through international cooperation on the scientific aspects of disarmament. Investing in such research has diplomatic benefits by providing concrete evidence of Nuclear Weapon States taking seriously their obligations to pursue disarmament under the NPT.

This cooperation could catalyse the political conditions necessary for multilateral disarmament by helping to build much needed trust between states. Since all states will be stakeholders in any future disarmament process, international cooperation must also include Non-Nuclear Weapon States from the outset to ensure the transparency of this process. The scientific community often works beyond national boundaries on problems of common interest and so is well-placed to help prepare the foundations for future multilateral negotiations.¹

The timescale for complete nuclear disarmament will be long, and so focusing now on the detailed challenges of the final stages of the process may be premature. A more practical approach might be to establish the scientific requirements of a monitoring and verification system to support future negotiations, especially when this can produce tangible and immediate improvements to international security.

Scientific cooperation is also essential in related non-proliferation and arms control areas to ensure that new instabilities are not introduced that could undermine nuclear disarmament. This includes research into: managing the civilian nuclear fuel cycle; improving the physical security of nuclear material and facilities; verifying a Fissile Material Cut-Off Treaty; and strengthening the Comprehensive Test Ban Treaty.

Given the growing political momentum for nuclear arms control and disarmament, the scientific community has an opportunity to advise the international community about this research and the cooperation needed to carry it out. Disarmament laboratories have the potential to develop a

truly international approach. They could help facilitate exchange not just between states; but also between government, industry and academia so that the latest scientific advances can be integrated into the development of solutions to the challenges that lie ahead.

2 The nuclear non-proliferation regime under stress

Currently, there are 189 States party to the NPT, five of which (China, France, Russia, UK and USA) are officially recognised under the treaty as Nuclear Weapon States (NWS). Three non-party States are known to possess nuclear weapons, namely India, North Korea, and Pakistan, while one other, Israel, is also believed to possess them. At the heart of the NPT is a 'grand bargain' according to which the NWS pursue negotiations with all NPT States to dismantle their nuclear weapons while Non-Nuclear Weapon States (NNWS) agree to forsake acquiring or developing nuclear weapons.

Under this bargain, the NPT allows for the transfer and use of nuclear technology by NNWS as long as they submit to International Atomic Energy Agency (IAEA) safeguards to ensure it is solely for peaceful purposes. Enrichment and reprocessing technologies are considered to be the most sensitive nuclear technologies since they are intrinsically dual-use. Technologies to enrich uranium to the low levels necessary for use in nuclear fuel can also enrich it to the higher levels necessary for nuclear weapons. Once it has been burned in a reactor, nuclear fuel can be reprocessed so that the energy-rich plutonium it contains can be reused as fuel, but this also separates out plutonium into a form that could be used in nuclear weapons. States with these capabilities have in effect a latent nuclear weapons capacity, which they could implement should they ever decide to pursue them.

Some commentators have argued that the nuclear non-proliferation regime may be as fragile today as the global financial system, pointing out that '*...the world dare not wait for a catastrophic collapse of the non-proliferation regime. From the consequence of such an event there is no feasible bailout.*'² It is under intense stress due in part to the cases of Iran and North Korea. If these NPT

signatory states become accepted as *de facto* possessors of nuclear weapons, much like the NPT outliers India, Israel and Pakistan, then this would undermine the security value at the heart of the NPT.³ Some fear this could lead to further proliferation as certain countries in the Middle East and Southeast Asia might reconsider whether their security interests are better served by developing nuclear weapons rather than forsaking them.⁴

Another source of stress is the future viability of the grand bargain at the heart of the NPT due to the perceived lack of progress towards nuclear disarmament. This may undermine the international cooperation required to resolve the cases of Iran and North Korea and to prevent further nuclear proliferation. To improve the chances of success at the forthcoming NPT Review Conference, NWS have therefore been reassessing their part of the grand bargain to demonstrate that they are making tangible progress towards disarmament. This will be crucial to encourage the NNWS that are complying with their obligations under the NPT to strengthen the non-proliferation regime as a whole. Meanwhile multilateral nuclear disarmament has once again become a topic of serious policy debate around the world.

3 Building political momentum for nuclear disarmament

3.1 The 'Gangs of Four'

Perhaps the most high profile catalyst for serious debate about nuclear disarmament was a January 2007 op-ed in *The Wall Street Journal* by the so-called 'Gang of Four' in which they set out a vision of a world free of nuclear weapons.⁵ Political momentum was sustained with the election of President Obama, who launched a series of diplomatic initiatives that focused on nuclear non-proliferation and disarmament. This contributed to him being awarded the Nobel Peace Prize less than a year after taking office.

In 2009, the United Nations Security Council voted unanimously for Resolution 1887, which called upon all States Parties '...to pursue negotiations in good faith on effective measures relating to nuclear arms reduction and disarmament, and on a Treaty on general and complete disarmament under strict and effective international control', as set out in Article VI of the treaty.⁶

On the other side of the Atlantic, former UK Foreign Secretary, Margaret Beckett, asked what concrete steps could be taken on multilateral disarmament.⁷ She called for the UK to become a '*disarmament laboratory*', which former Defence Secretary, Des Browne, later defined as '*... a role model and testing ground for measures that we and others can take on key aspects of disarmament. In particular, measures needed to determine the requirements for the verifiable elimination of nuclear weapons*'.⁸

In June 2008, the UK's own 'Gang of Four' added their support to the disarmament cause.⁹ These individuals and others recently formed a cross-party Top Level Group of UK Parliamentarians, comprising former military Chiefs of Defence staff, former Defence and Foreign Secretaries and a former NATO Secretary General. Having been collectively responsible for British defence and foreign policy for the last 20 years, this Group now advocates multilateral nuclear disarmament and non-proliferation.¹⁰

In 2009, a German 'Gang of Four' added European support,¹¹ now joined by comparable initiatives in Belgium, France, Italy, and the Netherlands. And in April 2009, Russian President Medvedev added his support to disarmament through a joint statement with President Obama.¹² Later that year, the report of the International Commission on Nuclear Non-Proliferation and Disarmament (ICNND), set up by the Australian and Japanese governments, identified practical steps that could be made over the short, medium and long term to realise the vision of a world free of nuclear weapons.¹³

3.2 Getting beyond the political impasse: a role for science diplomacy

Although there is now significant support for multilateral nuclear disarmament, significant political challenges remain.¹⁴ For example, it is not clear how the five recognised NWS under the NPT can make progress on disarmament when there are four states with nuclear weapons outside the NPT. Moreover, nuclear weapons are entrenched in national defence and foreign policymaking and associated bureaucracies. There are differing opinions over nuclear disarmament among foreign and defence ministries, especially in NATO countries, as well as a lack of trust between States. In addition, some commentators argue that reducing the role of nuclear weapons in defence policy could lead to instability through less restraint on conventional warfare.

Despite the difficulties in making progress on the political aspects of nuclear disarmament, opportunities exist for international cooperation to make progress on the scientific aspects. Investing in this would pay diplomatic dividends by providing concrete evidence of NWS taking seriously their obligations to pursue disarmament. It could also build trust to help catalyse the political conditions necessary for multilateral disarmament.

The timescale for complete nuclear disarmament will be long, so focusing now on the detailed challenges of the final stages of the process may be premature. A more practical approach might be to establish the scientific requirements of a verification system necessary to support future negotiations. The scientific community can make a valuable contribution by developing technologies to monitor whether States are complying with their disarmament obligations and to detect any non-compliance. International cooperation here can help build the necessary trust for states to undertake wider political negotiations. Furthermore, these technologies can simultaneously be applied to improve international

security in related areas.¹⁵

4 Scientific cooperation to prepare the foundations for future negotiations

Since Russia and the USA possess over 95% of the world's nuclear weapons, they remain the focus of efforts to reduce nuclear weapon stockpiles. They are now looking to complete a follow-on to the Strategic Arms Reduction Treaty (START), which expired in 2009. At some point they will not be willing to make further reductions without addressing the stockpiles of other NWS, starting with China, France and UK, and also those states with nuclear weapons outside the NPT. They therefore need to prepare the technical groundwork so that they will be ready to enter multilateral negotiations in due course.

4.1 Fissile material and nuclear weapons accountability

To begin the disarmament process, accurate declarations of existing stockpiles of fissile material and nuclear weapons need to be established to provide the baseline data against which to verify whether a state is complying with its disarmament obligations. This data would also provide immediate non-proliferation and counter-terrorism benefits by helping states maintain effective control over their fissile material, thereby reducing the risk of its theft, loss or unauthorised use.

By focusing on fissile material in the first instance, international cooperation could act as a useful confidence building measure by developing common accountability standards and formats, and evaluating information technologies for securely controlling access and exchanging information.¹⁶ This could begin with an international review of the methods described in the 2005 report of the US National Academy of Sciences (NAS), *Monitoring Nuclear Weapons and Nuclear Explosive Materials: An Assessment of Methods and Capabilities*.¹⁷

4.2 Transparency of the dismantlement process

Having established these declarations, states could then embark on the warhead dismantlement process, which is characterised by the following stages:

- transferring nuclear weapons from where they are deployed to a storage location;
- transferring a nuclear weapon from the storage location to a dismantlement facility;
- authenticating and then dismantling the warhead;
- monitoring the storage of its dismantled components;
- transferring these warhead components to other sites for disposal;

- destroying or converting relevant facilities used to manufacture nuclear weapons;
- ensuring there are no clandestine nuclear weapons, materials or facilities.

Since both NWS and NNWS will be stakeholders in any future disarmament process, international cooperation is essential from the outset to identify their respective transparency needs.

Perhaps the most significant challenge is providing transparency without revealing proliferation-sensitive or classified information about nuclear weapon design. START and its follow-on do not have mechanisms to verify the dismantling of nuclear warheads, but this will be the focus of future treaty negotiations for nuclear disarmament. This creates an opportunity to engage other countries to develop solutions jointly.

The UK's Atomic Weapons Establishment (AWE) has been carrying out a collaborative research programme with laboratories in Norway and assisted by the non-governmental Verification Research, Training and Information Centre (VERTIC) in four key areas:

- developing technology to identify and authenticate nuclear warheads without revealing proliferation-sensitive or classified information about their design;
- establishing chains of custody to track nuclear warhead components once warheads have been dismantled;
- monitoring storage of these dismantled components to ensure they are not clandestinely removed;
- managing access to allow international inspectors access to sensitive facilities without jeopardising security.¹⁸

This has proven successful in helping each side gain a better understanding of their respective transparency needs as a NWS and NNWS.¹⁹ Similar bilateral partnerships could be set up based on the UK-Norway model.²⁰

There are lessons, both technical and political, that can be learned from the experience of chemical and biological weapons disarmament. For example, information barrier technology and managed access for inspections was addressed in the development of the monitoring regime to protect commercial information as part of the Chemical Weapons Convention (CWC). The failure of governments to complete negotiations on a verification system for the Biological Weapons Convention (BWC) highlights the reality of political demands on verification. Verification can never be perfect, but developments in science and technology can help work towards higher degrees of confidence.

4.3 International disarmament laboratories

The concept of a disarmament laboratory has the potential to realise a truly international approach to the design, testing and implementation of these

approaches.²¹ Not only could disarmament laboratories facilitate cooperation between NWS and NNWS; but they could also provide a means for governmental, non-governmental and intergovernmental collaboration. They could draw on existing research on nuclear arms control and non-proliferation carried out at nuclear weapons laboratories, as well as facilitating partnerships between government, industry and academia so that the latest scientific advances can be integrated into the development of technology and policy solutions. Similarly, they could allow interactions with the IAEA so that its experience in developing multilateral solutions for nuclear safeguards and nuclear security can be brought to bear on the challenges of disarmament.

Moreover, there are precedents for such facilities. For example, in the USA these include: the Cooperative Monitoring Centre at Sandia National Laboratories; the Nevada Test Site; and the Technical On-Site Inspection facility at Kirtland Air Force Base (which was specifically designed for developing arms control technology and related exercises). Russia has also conducted a number of demonstrations as part of cooperative non-proliferation programs with the USA at various Rosatom and Ministry of Defence facilities. The European Commission's Joint Research centre at Ispra in Italy has expressed interest in creating an international centre for nuclear disarmament research under the auspices of the IAEA.²²

5 Scientific cooperation to reduce instabilities affecting nuclear disarmament

Analysing the potential of various technologies to support a monitoring and verification system for disarmament will be directly applicable to a variety of related efforts, including:

- managing the civilian nuclear fuel cycle;
- improving the physical security of nuclear material and facilities;
- verifying the Fissile Material Cut-Off Treaty (FMCT);
- strengthening the Comprehensive Test Ban Treaty (CTBT).
- This will help ensure that new instabilities are not introduced that could negatively affect nuclear disarmament.²³

5.1 Managing the civilian nuclear fuel cycle

Since the civilian nuclear fuel cycle poses potential proliferation risks, it needs to be carefully managed, especially if there is a global expansion of nuclear power.²⁴ To help address this problem, the UK government is setting up a Nuclear Centre of Excellence to '*...to improve the access to the peaceful use of nuclear energy by further developing proliferation resistant*

nuclear technology'.²⁵ This technology may help reduce the capacity of states to develop nuclear weapons based on civilian nuclear power programs. However, both its potential and limitations will need to be assessed.²⁶

At the same time, new governance norms for the fuel cycle are being developed. Current attention is focusing on placing enrichment and reprocessing capabilities under international control, which was stressed by the UK Prime Minister in 2009 when calling for multilateral control of the nuclear fuel cycle.²⁷ Such a governance mechanism would support a comprehensive monitoring system needed to verify a ban of all nuclear weapons.²⁸

Serious questions remain about the 'back end' of the fuel cycle, namely the disposition of plutonium and spent nuclear fuel. As the UK Prime Minister added, '*...most of the options proposed are aimed at the front half of the fuel cycle.... I believe we should now go further in considering all the options, including those that can address the challenges of handling spent fuel in a more secure way*'.²⁹ No country has completed the development of a long-term repository for nuclear waste, and the economics of reprocessing spent fuel remains contentious. Further research on reprocessing, spent fuel disposition, and proliferation-resistant reactor design will be necessary. These debates will need to involve not just policymakers and industry, but also scientists and the non-governmental community. Furthermore, if new governance norms for the fuel cycle are to be deemed fair and truly international, then the views of NWS, NNWS and countries outside the NPT also need be considered. The Royal Society has recently embarked on a new project to investigate many of these issues.³⁰

5.2 Improving nuclear security

Another source of instability is the potential acquisition of nuclear weapons by non-State groups, such as criminal or terrorist organisations. Although debate continues over the intent and capabilities of these groups, there is no doubt that serious weaknesses exist in securing nuclear materials and facilities worldwide.

The US Administration is organising a Global Nuclear Security Summit to address these issues in April 2010. King's College London and the Royal Society recently co-hosted a Nuclear Security Conference in February 2010, which brought together scientists, academics and policymakers to help officials prepare for the summit. The Fissile Materials Working Group, a group of 27 non-governmental organisations, will also be hosting an international meeting the day before the summit to help build consensus on policy proposals.

Many of these efforts to improve nuclear security have significant technical requirements. This creates an opportunity to engage the scientific community, especially in cutting edge research to develop novel nuclear detection and forensics techniques.³¹ In 2007, the Royal Society organised a workshop to bring academics and government scientists together to explore innovative detection methods.³² In 2008, the American Association

for the Advancement of Sciences (AAAS) published a joint study with the American Physical Society (APS) on nuclear forensics, which noted that international cooperation will be essential to ensure the credibility of these efforts.³³

The focus on threats posed by non-State groups has also initiated discussions about the future role of nuclear weapons laboratories. They may need to have a broader national security role beyond nuclear weapons.³⁴ However, as nuclear stockpiles are reduced, technical skills and special facilities may need to be maintained to certify the safety, security and reliability of the remaining weapons. Similar skills will be necessary to verify the disarmament process, as well as helping to prevent, detect and respond to acts of nuclear proliferation and nuclear terrorism.

5.3 Verifying a Fissile Material Cut-Off Treaty

Instability may also be created by the production of fissile material for non-peaceful purposes. After the Cold War, the UN General Assembly called for the negotiation of a multilateral and effectively verifiable Fissile Material Cut-Off Treaty (FMCT), banning the production of fissile material for nuclear weapons or other nuclear explosive devices. Under the NPT, NNWS already commit themselves to not producing fissile material for weapons and are subject to stringent verification by the IAEA. NWS are not committed in this way, and so a FMCT is important for nuclear disarmament as it would impose new limitations on the five NWS recognised by the NPT, as well as other countries with nuclear weapons.

Some of the verification challenges facing the FMCT include how to monitor enrichment and reprocessing facilities and the fissile material they produce after the cut-off date, and how to detect clandestine enrichment and reprocessing facilities. International cooperation on developing remote detection, nuclear forensics and nuclear archaeology techniques will be important. Such monitoring systems would be a vital part of the wider system to verify a ban on nuclear weapons.³⁵

While negotiations have been blocked, largely for political reasons, progress can still be made on technical issues associated with verifying a FMCT. This highlights an opportunity for so-called 'Track Two' diplomacy. Track Two diplomacy brings together individuals working outside the official negotiation process. Free of the constraints of formal governmental positions, a primary aim is to help prepare the groundwork for official negotiations by allowing participants to explore emerging issues of interest and overcome points of contention.

Some of the best known examples during the Cold War were the Pugwash Conferences on Science and World Affairs. Through the efforts of a wider group of independent scientists Pugwash contributed to agreement on issues, such as the NPT, BWC and CWC.³⁶ In 1980, the US NAS established a standing Committee on International Security and Arms Control (CISAC) and a counterpart group was set up at the Soviet Academy of Science. Ongoing dialogues between these groups

(starting in 1981) have been credited with helping to reduce tensions and for laying the groundwork for eventual dialogue between Presidents Reagan and Gorbachev.³⁷

Some non-governmental groups have already shown leadership on the FMCT, such as the International Panel on Fissile Materials (IPFM), which consists of an international group of arms control and non-proliferation experts from NWS and NNWS.³⁸ The Independent Group of Scientific Experts on the detection of clandestine nuclear weapons usable materials production (iGSE) has also been analysing techniques that are not yet employed by the international community.

5.4 Strengthening the Comprehensive Test Ban Treaty

The Comprehensive Test Ban Treaty (CTBT) can also reduce instabilities by preventing a qualitative nuclear arms race. The CTBT does not prohibit research on nuclear weapons but it is difficult to develop new nuclear weapons without nuclear testing. Despite many years of negotiations, the CTBT is yet to formally enter into force. However, the Preparatory Commission for the Comprehensive Test Ban Treaty Organisation (CTBTO) has been tasked with developing a system to detect clandestine nuclear explosions, and enable verification of the CTBT when it does enter into force.

Lessons for collaboration on nuclear arms control can be learned from the CTBTO. Approximately US\$1 billion has been spent over the last 12 years to build, operate and maintain a highly technical International Monitoring System (IMS), consisting of over 320 monitoring stations and 16 laboratories in nearly 90 countries worldwide, many of which are located in remote and inaccessible regions. Four complementary monitoring techniques are used. Seismic, hydroacoustic and infrasound stations monitor underground, the oceans and the atmosphere, respectively, while radionuclide stations supported by certified analytical laboratories detect any radioactive debris, which provides the signature of a nuclear event. Data recorded at the monitoring stations are relayed in real time to the CTBTO headquarters in Vienna, Austria, through a network of over 200 ground stations, six satellites and three major communications hubs.

The IMS is highly inclusive and transparent. Raw data from the monitoring stations are transmitted from the CTBTO headquarters to Member States since they (and not the CTBTO) are responsible for the technical and political judgment about the nature of events. Since some countries lack the necessary capacity or technical capability, both raw and analysed data are transmitted to Member States so that they can then make informed judgments.

As a unique global venture, the IMS illustrates why technical approaches to nuclear disarmament must be truly multilateral. No single country could establish, through bilateral means alone, the hundreds of monitoring stations required in many countries across the

world. However, complementary bilateral and trilateral approaches are still an important part of any process.

The IMS is based, in part, on the activities of the Group of Scientific Experts (GSE) that developed and tested approaches to the seismic monitoring of nuclear tests explosions from the mid 1970s to the early 1990s. Set up at the Conference on Disarmament in Geneva, the GSE was essential in laying the scientific groundwork for CTBT negotiations. Given the political impasse during the Cold War, the GSE set a precedent for how international science cooperation on nuclear arms control can still make progress despite a political climate that is not conducive to treaty negotiations. Today, the CTBTO remains actively engaged with the scientific community, having launched the International Scientific Studies project in 2008 to identify areas where the IMS can be strengthened based on the latest scientific developments.

6 Overcoming obstacles to scientific cooperation on nuclear arms control and disarmament

There are key lessons to be learned from past experience of collaboration on nuclear arms control, to ensure the success of future cooperation.

6.1 Awareness of the primary goals of cooperation

Goals for scientific cooperation may be varied. If the primary goal is to produce new knowledge, then projects should be selected using sound scientific principles, and should promote and instil international standards. If the primary goal is more political, then this is not necessarily problematic. For example, in some cases under the Cooperative Threat Reduction Program, former nuclear weapons scientists were redirected into civilian research mainly for non-proliferation goals. However, everyone involved must be aware of the primary goal. Without such clarity of purpose, expectations will diverge and cooperation could fail.

6.2 Political commitment to cooperation

Cooperation tends to be more successful where there is an equal relationship between partners. Even if the relationship is unequal, however, cooperation can still succeed if both sides agree that they are solving an important problem of common interest. Sufficient funding must be provided, and the boundaries of sensitive discussions must also be clearly identified. The nuclear relationship between UK and USA under the 1958 Mutual Defence Agreement is unequal relationship yet it illustrates how there can still be high levels of trust and transparency between two NWS.

6.3 A legal framework to protect scientists

Science cooperation can be left exposed and vulnerable if appropriate legal frameworks are not put in place to insulate scientists from wider political dynamics. For example, in the late 1990s, scientists from Chinese and US nuclear weapons laboratories engaged one another on arms control technologies. However, the report of the Cox Commission in 1998 claimed sensitive security information was revealed during these discussions. Since then there has been no official collaboration between these two countries in this area. In contrast, Russian and US scientists have collaborated on common verification approaches. This was successful partly because the Warhead Safety and Security Exchange Agreement (which has now expired) clearly articulated the areas for scientific collaboration, thereby ensuring the work they were carrying out was of mutual benefit to both countries.

6.4 The potential for trilateral partnerships

Trilateral partnerships also offer potential benefits, particularly in cases where the bilateral relationship between two parties may be strained. A credible third party with strong bilateral relationships with each of the other two parties could act as an honest broker and spearhead science cooperation between them. For example, facilitated by the IAEA, the Trilateral Initiative was a six year effort to develop a verification system under which Russia and USA could submit classified forms of fissile material from nuclear weapons to the IAEA for monitoring and verification in an irreversible manner and for an indefinite period of time.³⁹ Lessons could be learned from this initiative to design a monitoring and verification system for multilateral nuclear disarmament.

6.5 Issues of classification

The NPT does not allow for the disclosure of proliferation sensitive information, materials, or technologies between States, and so cooperation between NWS and NNWS will require clear agreements on areas for discussion. Furthermore, what one nation considers to be classified information may not be considered as such by another. Nevertheless, international cooperation may require States with nuclear weapons to review their classification guidelines.⁴⁰ Information does not need to be made public now but it would facilitate the development of a verification system if there was a willingness to consider releasing it as part of a future multilateral process.⁴¹

7 Next steps for the scientific community

7.1 Providing independent advice to policymakers

Renewed political support for nuclear arms control and disarmament provides the scientific community with an opportunity to advise the international community about the technical challenges involved, and to identify the research and international cooperation necessary to address them.

A priority is to ensure that this scientific advice is independent and reliable, and that mechanisms are available for it to effectively inform policymakers. National academies, learned societies, scientific organisations, and individual scientists are a valuable source of this independent advice.⁴²

For example, the Royal Society has been advising the UK government for over a decade on the management of its civilian stocks of fissile material, which is a key component of the nuclear arms control and disarmament agenda. At over 100 tonnes, the UK has the world's largest civilian stockpile of separated plutonium, and until now this stockpile had grown without any strategy for its long term management. In 2007, the Royal Society published *Strategy options for the UK's separated plutonium*, and it remains actively engaged with the UK Government as it deliberates about how to manage this stockpile.⁴³

Similarly, AAAS Centre for Science, Technology and Security Policy (CSTSP) helps policymakers gain access to the latest technical thinking on a broad range of issues relating to science and national security. The recent CSTSP study, *The United States Nuclear Weapons Program: The Role of the Reliable Replacement Warhead*, has had a significant impact on the US Congress and government agencies.⁴⁴

The science community needs to present a range of verification options to policymakers and explain the various tradeoffs involved, including the complexity, vulnerability, cost, levels of confidence, and time needed to develop them. It also needs to identify where uncertainties exist or where the evidence base is inadequate.

For example, after the US Senate failed to its consent for ratification of the CTBT in 1999, the National Academy of Sciences was asked to review the technical concerns raised during the debate. These focused on a lack of confidence in the verification system for the CTBT and uncertainty about the ability to maintain the safety and security of the US nuclear stockpile in the absence of nuclear testing.⁴⁵ The NAS was asked by the White House to review and update this report so it can be used to support debate when the Senate considers ratifying the treaty again.

Since these uncertainties have the potential to undermine international negotiations, cooperation between nations

is crucial to bridge knowledge gaps and minimise ambiguities. For example, the NAS and the Chinese People's Association for Peace and Disarmament recently collaborated on the first *English-Chinese, Chinese-English nuclear security glossary* '...to reduce the likelihood of misunderstanding, and to remove barriers to progress in exchanges and diplomatic, cooperative, or other activities where unambiguous understandings are essential.'⁴⁶ Such an activity could be expanded to other countries.

It is important to manage political expectations by communicating not just the potential but also the limitations of technology.⁴⁷ There is scope for collaboration between the natural and social sciences since the challenges posed by nuclear arms control and disarmament will need technical and non-technical issues to be considered together.⁴⁸

The capacity of the scientific community to advise national governments can be affected by issues of classification. Some commentators point out that different cultures of secrecy exist in different countries. One option would be to reappraise the types of information that need to be kept secret in each country. Increasing openness in a responsible way could improve security, and nuclear secrecy can even lead to greater insecurity.⁴⁹ However, scientists may need to be prepared to work in a classified environment to make credible arguments about declassifying certain information.

Another option is to make use of independent scientists who have security clearances. The NAS is perhaps unique among national academies of science because it carries out classified work. Members of the relevant NAS Working Groups have security clearances and the academy works closely with the government agencies concerned to carefully manage the process. However, the NAS is keen for unclassified versions of studies to be made publicly available to ensure transparency and build confidence in the advice provided.

Similarly, the JASON Advisory Group provides independent scientific advice to the US government on highly classified issues, including nuclear weapons, and it strives to provide unclassified summaries of its reports. It sets a useful model for other countries. For example, in the UK there has been debate about whether a JASON-like body should be established.⁵⁰ A multinational JASON Group could help advance multilateral nuclear disarmament.

7.2 Scientific advice at the international level

No international group focuses specifically on the scientific and technical challenges of nuclear disarmament, and so there have been some calls for a high-level group of international experts to advise governments and develop a framework for international cooperation.⁵¹

One of the best known examples of such a mechanism is the Intergovernmental Panel on Climate Change (IPCC). It does not carry out its own research but produces periodic

assessments of the latest scientific, technical and socio-economic research, drawing on contributions from scientists and other experts from all over the world. For example, in 2008 the Norwegian Minister of Foreign Affairs recommended the establishment of an Intergovernmental Panel on Nuclear Disarmament based on the IPCC model.⁵²

Such a panel could draw on the experience of the GSE. However, more analysis would be required to develop a concept appropriate for nuclear disarmament.⁵³ It should also learn from other nuclear disarmament activities, for example, in Belarus, North Korea, South Africa and Ukraine. Given the political sensitivities around nuclear arms control and disarmament, national academies of science and other scientific organisations could undertake initial Track Two activities.

List of acronyms

AAAS	American Association for the Advancement of Science
APS	American Physical Society
BWC	Biological Weapons Convention
CISAC	Committee on International Security and Arms Control
CWC	Chemical Weapons Convention
CTBT	Comprehensive Test Ban Treaty
CTBTO	Comprehensive Test Ban Treaty Organisation
FMCT	Fissile Material Cut-Off Treaty
GSE	Group of Scientific Experts
IAEA	International Atomic Energy Agency
iGSE	Independent Group of Scientific Experts on the detection of clandestine nuclear weapons usable materials production
IPCC	Intergovernmental Panel on Climate Change
IPFM	International Panel on Fissile Materials
IMS	International Monitoring System
NAS	National Academy of Sciences
NNWS	Non-Nuclear Weapon States
NPT	Nuclear Non-Proliferation Treaty
NWS	Nuclear Weapon States
START	Strategic Arms Reduction Treaty

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- ² Allison G (2010) Nuclear Disorder: Surveying Atomic Threats. *Foreign Affairs*, Vol 89, Issue 1, pp 74-85.
- ³ Johnson R (2005) Politics and Protection: Why the 2005 NPT Review Conference Failed. *Disarmament Diplomacy*, Issue No. 80.
- ⁴ It should be noted that the NPT regime has been successful in limiting the number of countries with nuclear weapons to nine.
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